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# Process of discovery: A fourth-year translational science course

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*Background:* The Liaison Committee on Medical Education notes the importance of educating medical students on clinical and translational research principles.
*Purpose:* To describe a fourth-year course, "Process of discovery," which addresses teaching these principles, and to discuss students' perceptions of the course.
*Methods:* Core components and pedagogical methods of this course are presented. Course assessment was performed with specific pre- and post-course assessments.
*Results:* During academic years 2004 to 2009, 562 students were enrolled, with assessment response rate of 94% pre-course and 85% post-course. The students' self-assessment of their current understanding of clinical and translation research significantly increased, as well as their understanding of how clinical advances will take place over the next decade.
*Conclusions:* A fourth-year course teaching clinical and translational research is successful, is seen as a positive experience and can meet the requirements for including clinical and translational research in the medical school curriculum.

Keywords: *medical students*; *clinical and translational research*; *basic science course*; *translational science course*; *fourth year course*; *medical school curriculum*

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## Background

In defining the educational objectives for medical education, the Liaison Committee on Medical Education (LCME) – the organization that accredits all medical schools offering the MD degree in the United States and Canada – states that the content of every curriculum should "introduce medical students to the basic scientific and ethical principles of clinical and translational research, including the ways in which such research is conducted, evaluated, explained to patients, and applied to patient care" (1). In doing so, the LCME recognized the importance of ensuring that students graduating from medical school have a firm understanding of clinical and translational research (CTR). A required one-month basic science course, to be given in the fourth year, was part of the redesigned curriculum at the University of Rochester School of Medicine and Dentistry in 1999, the double helix curriculum. This focuses on integrating basic science and clinical medicine throughout the four years of medical school. The "Process of discovery" (PoD) course was designed to meet this curriculum objective and had its first iteration in February 2004 as a required course. By the time students took PoD, they had completed core basic science courses and clinical clerkships and had the needed background to appreciate how basic science and CTR could lead to new, meaningful medical interventions at the bedside.

The purpose of this article is twofold: to describe a novel way of meeting this LCME standard by describing PoD, part of our basic science curriculum for fourth-year medical students; and to use pre- and post-course data derived from student surveys to assess how well PoD met its goal of teaching the process by which scientific discoveries find their way into clinical practice.



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## Methods

### *"Process of discovery" course description*

The intent of the PoD design, structure and implementation was to give students an understanding of CTR. PoD's learning objectives were to explain the bidirectional relationship between emerging knowledge and clinical care; to explain how the body of medical knowledge is built and advanced; and to define translational research. These objectives were embodied in a final project, in which students created research proposals describing how translational research can inform the development of diagnostic and therapeutic interventions.

PoD comprises three parts: two lecture series and a group project that encompassed both directed lectures and student organized activities. The heart of the course is the selection of two index diseases or themes (Table 1), chosen for their broad range of clinical problems, from prevention to cure or rehabilitation. The entire class – roughly 100 students – is divided into groups of seven to nine persons based on expressed career interests. If there are not enough students with the same career plans we group students with similar interests (e.g. neurology and neurosurgery, anesthesiology and emergency medicine, etc.). Senior faculty with research interests in areas related to the index cases serve as advisors to each group. The students are then given the assignment.

- Given what is known presently, and with additional resources (i.e. lots of funds), what specific plan would you put forward to improve diagnosis, treatment or management of the index disease over the next ten years?
- How will these advances in treatment or diagnosis ameliorate both the individual and the societal burdens of the disease?

The student groups are instructed to prepare a proposal for both oral and poster presentation addressing these two questions for the end of the course. Proposals may have greater or lesser emphasis on basic, translational or clinical research content, but regardless of the emphasis the students are expected to take a specific approach, research the current state of the art, determine major obstacles and suggest an approach to overcome these.

To assist the students in their work, in the first week faculty present lectures on the index diseases or themes – about six hours on each theme – to provide an up-to-date view of current research problems in these areas and identify important areas yet to be addressed by research. These lectures also introduce faculty who could serve as resources for advice on specific details of the projects. By the end of the first week, therefore, students can narrow the focus for their own proposals.

The other three weeks have a maximum of two hours of lectures per day, ensuring that students have ample time to work on their projects. The two lecture series were "Process of discovery" and "Frontiers of basic medical science." The PoD lectures addressed the process by which a laboratory discovery, such as the development of a lead compound, is taken forward into animal trials, the phases of human clinical trials, FDA approval and introduction into common clinical use – going from "bench" to "bedside" to "practice," including a discussion of commercialization (2). These lectures are given by scientists active in each phase of discovery (3). The "Frontiers of basic medical science" lecture series provide an opportunity to showcase the faculty who are doing highly regarded research at the University of Rochester. These individuals were asked not to give a "usual" lecture on their research, but rather one that addressed their research area, why they pursued it and how their research might change clinical care over the next decade.

*Table 1.* "Process of discovery" index diseases

| Year | | Diseases |
|---|---|---|
| 2004 | Osteoporosis | Cardiomyopathy |
| 2005 | Osteoporosis | Cardiomyopathy |
| 2006 | Infectious disease | Neuroprotection |
| 2007 | Infectious disease | Neuroprotection |
| 2008 | Arthritis | Pediatric leukemia/lymphoma |
| 2009 | Arthritis | Trauma |

*Note:* The index diseases were selected as ones that were thought to have broad patient and societal impact, be common in every physician's practice and not possess any current fully effective therapies or preventive measures.

### *Course assessment*

Since this was a new course, we designed specific pre- and post-course questions (Table 2), used in addition to standard course assessment tools. Use of these data for publication received Institutional Review Board approval. The responses were measured on a 1–5 Likert scale. The responses on the pre- and post-course surveys were anonymous and thus it was not possible to link the data by student. The results were analyzed by ANOVA with factors: pre- and post-course survey, year, and pre-/post-course survey by year interaction. Statistical analysis was accomplished using the STATA software program.

## Results

A total of 562 students took PoD during the six academic years from 2004 to 2009. The response rates for the online questionnaires were 94% (92–100%) for the pre-course questions and 85% (62–99%) for the post-course questions.



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*Table 2.* Results of student pre/post-course survey questions

| | | Years | Pre-course | Post-course |
|---|---|---|---|---|
| Q1: How much will doing research be part of your career? | | 2004–2009 | 2.99 ± 1.06 (526) | 3.09 ± 1.01 (479) |
| Q2: How would you rate your current understanding of how new advances reach clinical practice? | | 2004–2009 | 3.08 ± 0.98 (526) | 3.66 ± 0.84* (479) |
| Q3: How important do you think research (basic, translational and clinical) is to improving our care of patients? | | 2004–2009 | 4.47 ± 0.79 (526) | 4.41 ± 0.77 (479) |
| Q4: How would you rate your understanding of the current issues in: | Osteoporosis | 2004–2005 | 2.65 ± 1.01 (181) | 3.72 ± 0.75* (162) |
| | Cardiomyopathy | 2004–2005 | 2.15 ± 0.95 (179) | 3.57 ± 0.80* (157) |
| | Infectious disease | 2006–2007 | 2.84 ± 0.90 (179) | 3.71 ± 0.72* (173) |
| | Neuroprotection | 2006–2007 | 2.94 ± 0.78 (179) | 3.68 ± 0.75* (173) |
| | Arthritis | 2008–2009 | 2.59 ± 0.92 (165) | 3.59 ± 0.78* (143) |
| | Pediatric leukemia/lymphoma | 2008 | 2.48 ± 0.96 (84) | 2.78 ± 0.93* (64) |
| | Trauma | 2009 | 2.96 ± 0.98 (81) | 3.95 ± 0.70* (79) |
| Q5: How well do you think your medical education at the University of Rochester has prepared you to understand the clinical advances that will take place over the next decade? | | 2004–2009 | 3.80 ± 0.85 (524) | 4.06 ± 0.76* (479) |
| Q6: How important is it for there to be a basic science course in the fourth year of the current curriculum? | | 2004–2009 | 2.66 ± 1.08 (525) | 2.98 ± 1.21* (477) |

*Note:* *p < 0.01 pre-course versus post-course.

### Importance and preparedness

The students were not overly enthusiastic about the importance of a basic science course in their fourth year (Table 2, Q6); however, their opinions improved after the course, although still below the midpoint on the Likert scale. Prior to the course the students thought that our curriculum prepared them well to understand advances that may come in the next decade; this confidence improved further after the course (Table 2, Q5).

### Research: Interest, importance, understanding

The students' (including MD/PhD students and others who had considerable research experience) interest in and experience with research was variable. As a whole they were moderately interested in having research as part of their career; this did not change as a result of the course (Table 2, Q1). Although there was a significant variation by year ($p = 0.03$), this appeared to be random. They were more enthusiastic in thinking that research is important in improving clinical care, and this did not change after the course (Table 2, Q3), nor did it vary significantly by year. With regard to students' understanding of how new advances reach clinical practice, a statistically significant improvement was noted (Table 2, Q2).

### Index disease knowledge

The students generally rated their knowledge of the current index diseases issues as below the midpoint on the Likert scale (Table 2, Q4) prior to the course. After the course, the students' rating of their understanding of the index diseases significantly improved and all but one index disease was above the midpoint in the Likert scale.

### End-of-course evaluations: Positives and negatives

Student end-of-course evaluations were reviewed and comments were evaluated qualitatively. The most frequent comments, both positive and negative, were tracked and recorded, and then grouped into the most common themes. Evaluations allowed students to comment on course strengths and weaknesses, and prompted them to include any additional comments they had on the course. A theme was assigned to each comment and themes were totaled and ranked; those occurring most frequently are shown in Table 3. The top four positive-comment themes focused on course structure and leadership, with particularly positive feedback about the independent small-group project opportunity and the grouping of students together based on expected residency specialty. Negative-comment themes were grouped into the areas of course timing and length, as well as "too much basic science." Highlights and examples of positive and negative comments are also provided in Table 3.

*Table 3.* Student course evaluations themes and examples

| Theme | Example |
|---|---|
| | **Positive comments** |
| Strong course director | "The course director was very enthusiastic and really seemed to care about our learning process." |
| Good lectures | "I thought that overall the lectures were all really interesting and enjoyable. There was a nice variety of topics that could appeal to people regardless of their plans for the future." |
| | "Some of the best lectures were the ones where people talked about what they had done and how they got involved in research." |
| Small-group projects | "The small-group projects were invaluable learning tools that 'forced' me to apply class lectures. I learned the most by working with my group to come up with the poster and presentation." |
| Groups by specialty | "It was nice to work in groups with people who are going into the same or similar fields." |
| | **Negative comments** |
| Timing of course | "This is an inopportune time to be doing such a class. The end of fourth year should be devoted to electives which will be useful during intern year." |
| | "It would be more useful to have PoD earlier in the curriculum so that students who are interested in research gain a sense of how to develop a project idea. Moreover, the course could pique interest in students who never recognized their personal interests in research and would allow them to possibly pursue research opportunities during their medical school career that they may not have pursued otherwise." |
| | "PoD doesn't seem to fit into fourth year. Many of us have already actively pursued our own research and chosen our career paths." |
| Course length | "Four weeks is too long for this course. The lectures could have been condensed and small-group projects done earlier." |
| Limited choice for project | "I would have preferred to work on a project related to my future profession rather than being forced to choose between two specific diseases." |
| Too much basic science | "I felt that many of the basic science lectures went back to the basics so much that I lost interest and focus. I feel that if the lectures were more clinically relevant, I would have been more interested." |

## Discussion

We describe a fourth-year course that addresses the LCME standard of teaching medical students "basic scientific and ethical principles of clinical and translational research, including the ways in which such research is conducted, evaluated, explained to patients, and applied to patient care" (1).

The course falls in line with an increasing trend among medical schools to reintroduce basic science concepts in what have traditionally been the clinical years. The concept of medical school curricular reform with emphasis on integration of basic science into the clinical years was first introduced in the 1970s and 1980s. The McGill curriculum was developed in the 1970s and reported on in 1984 by Patel and Dauphinee (4). They described a curriculum that included fourth-year medical students participating in a series of three-month integrated courses in traditional basic science subjects. Croen et al. (5) reviewed US medical school curricula, reporting that in 1985 17 of 130 US medical schools (13%) required a basic science course during the third or fourth years. In their 1986 article, they also described their experience at the Albert Einstein College of Medicine with an eight-week basic science course which was developed in the mid-1970s. The course was primarily lecture-based at its inception, but evolved into a multidisciplinary case conference series presented prior to starting the fourth year. Subsequent reports are limited in number, most articles emphasizing the challenges associated with incorporation of basic science into the clinical years (6–9). In 1998 Schmidt (7) summarized the experience at eight anonymous US medical schools, and described difficulties including challenges in collaboration between basic and clinical scientists, as well as varied teaching formats. Little information was available about outcomes related to these attempts at curricular reform during the final two years of medical school.

In 2008 Spencer and colleagues (10) noted a modest increase in basic science courses during the clinical years for US medical schools – 19% versus 13% found by Croen et al. (5). Interestingly, by 2007 24% of Canadian medical schools had implemented required basic science curricular components during the final two years. Despite these increased efforts, they noted a large variation in teaching methods and curricular time. Course duration averaged four weeks, with a range of one week to 12 weeks.



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In our PoD translational science course we noted a significant change in student attitude in a number of areas, including current understanding of how new advances reach clinical practice, importance of a basic science course in the fourth year curriculum and improved understanding of current issues in the index diseases. Questions 2 and 3 in Table 2 (rating current understanding of how new advances reach clinical practice and the importance of research to improving our care of patients) are central to the objectives of PoD; the changes in student attitudes underscore the success of the course.

Despite a positive change in student attitude in these areas, it is not surprising that pre- and post-course data revealed no changes in the students' assessment of whether research will be part of their career, or the importance of research in improving patient care. It is unlikely that a four-week experience during the fourth year would change students' short-term research interests, although the long-term effect may be more positive. In addition, the qualitative review of student evaluations and the top negative themes emphasize the challenges facing course directors and faculty participants in such a course (Table 3).

The most frequent negative theme was the timing of the course within the curriculum. The curriculum committee felt that February of the fourth year was the most appropriate time, since there are drawbacks earlier and later in the fourth year. For example, a summer course would conflict with sub-internships; an autumn or early winter course would conflict with residency interviews; and a spring course would risk complete loss of student commitment, being so close to graduation. Course length was also a frequent negative-comment theme. Shortening the course from four to two weeks was often mentioned by the students, but the PoD course director and faculty have found immersion of the students back into basic science mode requires more than two weeks, especially when focusing on providing necessary background knowledge to understand index diseases better and allowing for meaningful small-group project creation.

The positive-comment evaluation themes (Table 3) underscore some of the strengths of the chosen format. In particular, students were very positive about the small-group projects as effective learning tools intended to spur them to integrate knowledge gained via the two lecture series. In addition, they were enthusiastic about the small-group clustering of students by intended specialty, and reinforced the benefits of the course placement at the beginning of the second half of the fourth year. A committed and enthusiastic course director also seemed to be essential.

It is important to note the limitations of the current report. Although the data are based on six consecutive years of operation, this only reflects the experience at our institution, and it is unclear how this experience translates to other student groups or medical schools. In addition, we describe and report on outcomes of a single format and method of teaching with measurements based on students' perceptions rather than an independent measurement of outcomes. PoD is only one method of introducing students to CTR and its central role in the advancement of clinical medicine (10). The goal of revisiting basic science in the third and fourth years is to offer students a better understanding of how new approaches to important diseases are developed and integrated into clinical practice, i.e. the process of clinical and translational research. Yet the intermediate- and long-term effects of such a course and experience are not clear. Further work is needed to determine if a change in attitude during the second half of fourth-year medical school influences efforts and accomplishments during residency or a practice career.

In conclusion, this article describes an innovative approach to integrate a basic science course that emphasizes the role of translational and clinical research teaching during the clinical years of medical school. Resulting assessment data allow a better understanding of the ways in which students benefit from the experience. The strength of the information obtained is bolstered by the prospective data collection and the high participation rates. The consistency of course timing, format and message throughout its history are added strengths. Having a basic science course in the fourth year that teaches CTR – after students have completed both basic science and clinical core course requirements – is a novel, effective way to fulfill the LCME CTR standard.

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